Sr-Rb Age Determination of a Precambrian Rock from Lake County Ohio

by

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The Ohio State University

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Approved: G. Faure

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Abstract

The objective of this thesis was to date a Precambrian rock from the basement of Ohio. The Precambrian sample came from a disposal well drilled in Perry Township in Lake County, Ohio. The rock, which was of a granitic composition with secondary dolomite, was dated by the Rb-Sr whole rock method. The date of the rock was found to be 566±45 million years.

I. Introduction

The objective of this thesis was to date a Precambrian rock from the basement of Ohio. The Precambrian basement under Ohio is not exposed at the surface, consequently little is known about the age of these rocks. Therefore any absolute ages determined from the basement under Ohio would be very valuable.

The 4 inch diameter core was obtained by The Ohio State Geologic Survey from a disposal well drilled by Calhio Chemicals Inc. under Permit No. 142. The well is located in Perry Township of Lake County, Ohio. Figure 1 shows a map of Perry Township and the location of the well.

II. Description of the core

The well was drilled to a total depth of 6072 feet, with the Precambrian section constituting the last 12 feet of the core. Overlying the basement unconformably is The Mount Simon Formation, a pure quartz sandstone of Cambrian age.

Inspection of the Precambrian section of the core revealed that its mineralogy and textural character varied widely. The first 4 feet of the core is primarily a fine grained chlorite schist. Chlorite makes up approximately 75% of the rock with a reddish tinted mineral, possible microcline, making up 15-20% of the rock. The reddish color may be due to finely disseminated iron opaques. The remainder of the rock is minor pyrite. This whole section is highly fractured and

marked by slickensides dipping 30 to 60 degrees, assuming the core is vertical. The highly fractured zone grades into a non-fractured zone 1.5 feet thick where the sample for dating was obtained. Its mineralogy will be discussed in more detail later. This section grades into a 2 foot fine grained zone with a mineralogy of approximately 45% feldspar, 30% dolomite, 20% quartz and 10% chlorite. The dolomite occurs in the rock as small grains as well as numerous veinlets cutting the rock. The next 2.5 feet is again a chlorite schist with its mineralogy and textural character being the same as the previous chlorite zone. This zone grades into a one foot zone of a fine grained basic rock, probably a diorite or gabbro. Mineral identification is difficult due to the fine grained nature of the rock. Finally the last 2 feet of the core is a chlorite schist identical to the two zones previously mentioned. Figure 2 shows a scale diagram of the core.

III. Description of the specimen used for dating

Hand specimen identification of the sample revealed that a medium grained reddish mineral makes up 75% of the rock, the remaining 25% being fine grained dark minerals with only chlorite being identifiable.

Thin section identification of the minerals present proved to be rather difficult, since much alteration of the rock was observed. Chlorite and dolomite were positively identified making up 10% and 15%, respectively. The chlorite

shows no apparent foliation, while the dolomite forms medium grained rhombs presumably of secondary origin. Iron opaques make up 5% of the rock, these being finely disseminated throughout the rock. The remaining 70% was tentatively identified as medium grained subhedral to anhedral feldspar and quartz containing many small inclusions. Simple twinning is observed in the feldspar as well as undulatory extinction in the quartz. Positive identification was attempted through the use of X-ray diffraction methods.

A General Electric X-ray Diffractometer (XRD-6) was used to make positive identification of the minerals present. Figure 3 shows 2θ angles observed on the strip chart with values recorded in the literature (Chao, 1969). Quartz and microcline make up 40% and 30% respectively with dolomite and chlorite 10% each. Opaques, sericite and zeolites were the other minor minerals present in the sample.

IV. Analytical procedures

The method used for dating the sample was the whole rock Rb-Sr method. A 1.5 inch slice of the sample section was cut out using a diamond saw. A piece of this section weighing approximately 50 grams was crushed to less than 200 mesh. The powder was then homogenized by rolling the powder on a sheet of paper. A 3 gram sample was taken and compressed into a pellet with a boric acid backing. This pellet was

placed in the X-ray fluorescence spectrometer for analysis of Sr and Rb concentrations. The spectrometer was scanned from 18 thru 39 degrees for the measurement and location of the Sr, Rb peaks and the baselines. The spectrometer was peaked on ZrK_{α} radiation to obtain as accurate results as possible. The first radiation measured was $MoK_{\alpha}C$ at 30.00°. The Sr peak at 36.85° was surrounded by asymmetrical baselines at 35.40° and 36.50°. The net Sr values were calculated by the use of the following equation:

$$\text{Net Sr} = \text{Value of Sr peak} - 2(B_1 - 0.40909(B_1 - B_2))$$

where B_1 and B_2 are the two baselines and 0.40909 is the slope of the line connecting the two baselines. The Rb peak at 37.99° was surrounded by symmetrical baselines at 37.40° and 38.58°. Net Rb values were calculated by adding the two baselines together and subtracting the sum from the Rb value.

$MoK_{\alpha}C$ and all baseline radiations were counted for 100 seconds, with the Sr and Rb radiations being counted for 200 seconds. Four labratory standards were used in the analysis. The standards AVG-1, GSP-1, BCR-1 and G-2 were run a total of 13 times and the sample #528 was run 12 times to reduce the experimental error of the measurement. Figures 4 and 5 show the data of the X-ray fluorescence portion of the experiment. The net Sr and net Rb values were divided by the MoK C radiation values then plotted on a graph to obtain the Rb and Sr concentrations in parts per million. Figures 6 and 7 show these

graphs. The Rb/Sr ratio of the sample was obtained by plotting on a graph the known Rb/Sr ratios of the standards against their known net RbK_{α}/net SrK_{α}. Since the net RbK_{α}/net SrK_{α} of the sample is known through calculation the Rb/Sr ratio can be determined from the graph. Figures 8 and 9 show the Rb/Sr ratios plotted against the net RbK_{α}/net SrK_{α} ratios.

The Sr^{87}/Sr^{86} ratio was determined by the use of a mass spectrometer. A 0.2 gram portion of the sample was dissolved in a concentrated mixture of HF and H_2SO_4 acids. This was done to form strontium salts. The solution was taken to dryness and a small amount of 2N HCL was added. This solution was then filtered and a Sr^{89} tracer added. The solution with the tracer was put on as ion exchange column (Dowex 50) and the Sr solution was eluted with 2N HCL. The Sr fraction was identified by the activity of the Sr^{89} tracer and was collected in a series of 15 ml. polyethylene beakers. Seven beakers of the solution were collected and tested for Sr^{89} radiation by the use of a Geiger Counter. The beaker with the highest counting rate was used for the mass spectrometer analysis, since it contained the highest concentration of strontium. A small drop of the liquid was evaporated on a tantalum filament of the Nuclide Corp. Model 6-60-S mass spectrometer. The filament was loaded into the mass spectrometer and the run started with Sr isotopes 88, 87, and 86 being measured in the scanning procedure. The run lasted almost

two hours before the last traces of Sr isotopes were burned off.

V. Presentation and interpretation of the results

The Sr and Rb concentrations determined by the X-ray fluorescence method were found to be 53.9 ± 0.65 and 35.9 ± 0.56 ppm for Sr and Rb respectively. The Rb/Sr ratio calculated to be 0.646 ± 0.008. The Sr^{87}/Sr^{86} ratio was calculated by using eight groups of six peaks each from the mass spectrometer run. This was found to be 0.7188 ± 0.0010. The main assumption made in the calculation of the date was that the initial Sr^{87}/Sr^{86} ratio would be set at 0.7040. The following equation was used to calculate the date of the rock:

$$t = \frac{1}{\lambda} 2.303 \log \left[\frac{Sr^{87}/Sr^{86}_{exp} - Sr^{87}/Sr^{86}_{initial}}{Rb^{87}/Sr^{86}} + 1 \right]$$

where t equals time and λ is the decay constant set at 1.39×10^{-11} years.

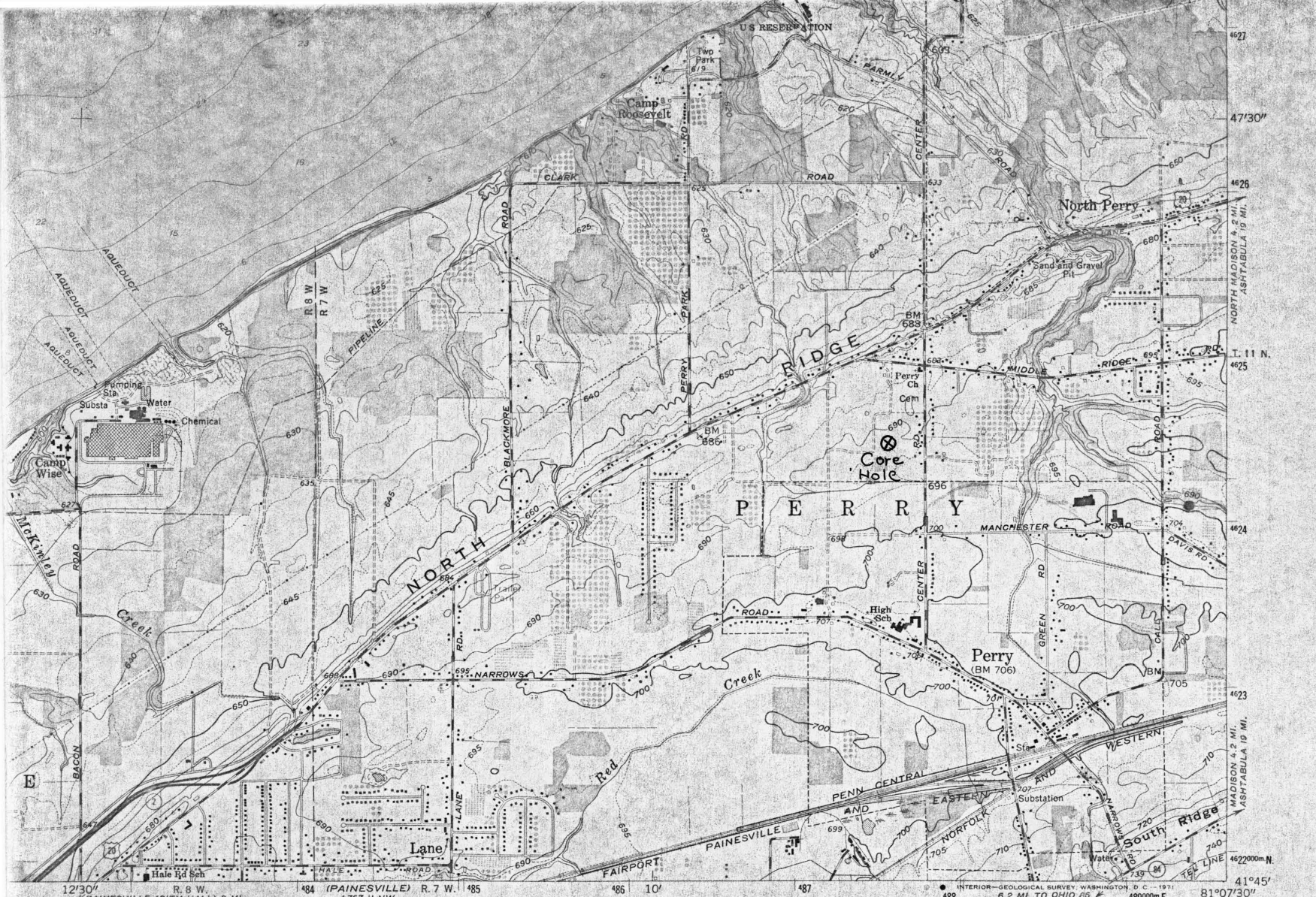
VI. Conclusions

The date of the rock was found to be 566 ± 45 million years. The date is younger than expected for rocks of the Grenville Province (approx. 900 million yrs.). The presence of the chlorite schist zones in the rock probably represented a shear zone. In a shearing event the Sr-Rb clock is many times reset along with metamorphic effects being induced in the

rock. The whole 12 foot core showed signs of shearing and low grade metamorphism which would explain the anomalous younger age of the rock. The date points out that the Grenville Province was tectonically active into Cambrian time.

VII. Acknowledgments

I would like to thank Dr. Arie Janssens of The Ohio State Geologic Survey for his co-operation in making the core available and also Dr. Gunter Faure for his help and advice during the course of this project.



SCALE 1:24000

1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
DOTTED LINES REPRESENT 5-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS LOW WATER 570.5 FEET

ROAD CLASSIFICATION

Medium-duty ——— Light-duty ———

Unimproved dirt - - - - - -

U. S. Route ⬡ State Route ◯

MAY 5 1971

QUADRANGLE LOCATION

PERRY, OHIO
SW/4 PERRY 15' QUADRANGLE
N4145—W8107.5/7.5

1960
PHOTOREVISED 1970
AMS 4767 I SW—SERIES V852

ETIC NORTH OF SHEET

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

Revisions shown in purple compiled in cooperation with State of Ohio agencies from aerial photographs taken 1970. This information not field checked.

Figure 1

Scale Drawing of the Core

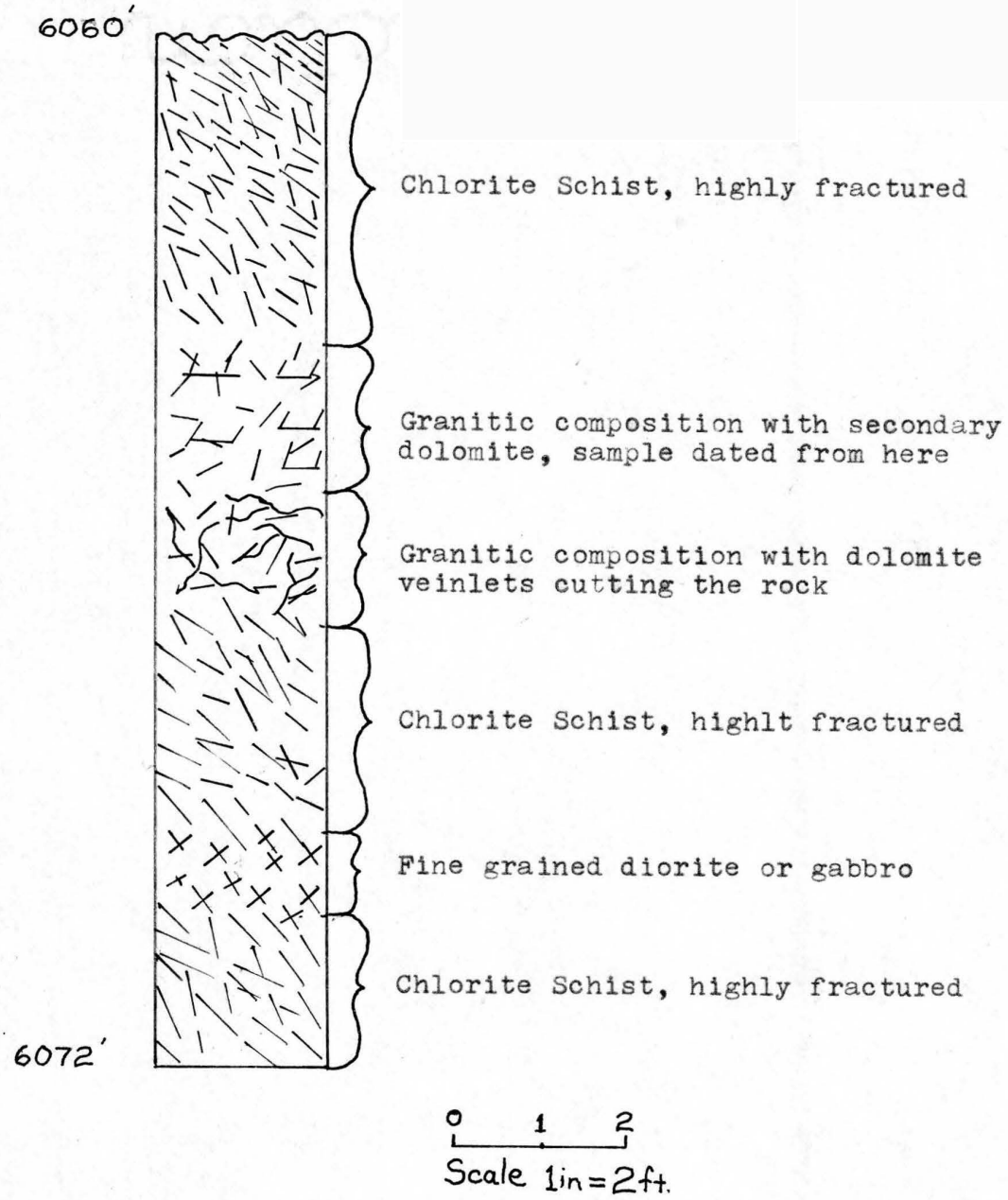


Figure 2

X-ray Identification

2θ angles in degrees (Cu)

Mineral	Observed 2θ(Cu)	Actual 2θ(Cu) (Chao,1969)	% Correlation
Chlorite (Kammererite)	12.4	12.38	99
	18.7	18.59	98
	24.9	24.81	99
	37.4	37.68	98
Quartz	20.9	20.83	99
	26.6	26.66	99
	50.4	50.21	98
	36.6	36.56	99
Dolomite (Ferroan)	30.7	30.84	99
	41.0	41.04	99
	50.6	50.36	98
	50.8	50.96	99
	23.4	24.05	97
Microcline	27.5	27.49	99
	21.8	21.10	97
	25.6	25.60	99
	30.4	30.15	98

Figure 3

Lake County, R. Vargo 3/23/72
65 KVP, 55 ma, LiF (220) peaked on Zr Kα 6.50V
E = 3.5, ΔE = 15.0

	Start	Mo Kα 30.00	B1 35.40	Sr Kα 35.85	B2 36.50	B3 37.40	Rb Kα 37.99	B4 38.58
Seconds →	PM	100	100	200	100	100	200	100
G-2	1:52	34403	4798	35597	3770	3446	14021	3132
528	2:12	27004	3324	8682	2981	2746	6487	2529
379	2:32	30024	3890	17307	3285	3073	13052	2788
GSP-1	2:52	31611	4045	19657	3450	3230	16177	2991
528	3:11	26968	3349	8737	3009	2770	6465	2569
379	3:31	30224	3865	17229	3273	3055	12958	2787
AGV-1	3:49	28512	4419	38368	3351	2944	8010	2704
528	4:09	26903	3325	8739	2980	2775	6531	2573
379	4:27	29999	3853	17154	3278	3048	12804	2804
BCR-1	4:45	22474	3216	17874	2657	2413	5903	2207
528	5:04	26837	3322	8604	2983	2789	6523	2524
379	5:23	29930	3844	17103	3290	3082	12840	2813
G-2	5:41	34238	4798	34953	3796	3437	13692	3147
528	6:00	26729	3337	8627	2977	2761	6436	2545
379	6:19	29989	3848	17072	3259	3082	12808	2787

	Mo Kα C	Sr Base	Sr Kα	Net Sr Kα	Net Sr / Mo Kα C	Rb Base	Rb Kα	Net Rb Kα	Net Rb / Mo Kα C	Net Rb / Net Sr
G-2	34403	8754	35597	26843	0.7802	6578	14021	7443	0.2163	0.2773
528	27004	6368	8682	2314	0.0857	5275	6487	1212	0.0449	0.5238
379	30024	7288	17307	10021	0.3335	5861	13052	7191	0.2395	0.7176
GSP-1	31611	7604	19657	12053	0.3813	6221	16177	9956	0.3150	0.8260
528	26968	6420	8737	2317	0.0859	5339	6465	1126	0.0418	0.4860
379	30224	7246	17229	9983	0.3303	5842	12958	7116	0.2354	0.7128
AGV-1	28512	7964	38368	30404	1.0664	5648	8010	2362	0.0828	0.0777
528	26903	6368	8739	2371	0.0881	5348	6531	1183	0.0440	0.4989
379	29999	7236	17154	9918	0.3307	5852	12804	6952	0.2317	0.7009
BCR-1	22474	5974	17874	11900	0.5295	4620	5903	1283	0.0571	0.1078
528	26837	6208	8604	2396	0.0893	5313	6523	1210	0.0451	0.5050
379	29930	7234	17103	9869	0.3297	5895	12840	6945	0.2320	0.7037
528	26729	6380	8627	2247	0.0841	5306	6436	1130	0.0423	0.5029
379	29989	7214	17072	9858	0.3287	5869	12808	6939	0.2314	0.7039

	Rb	Sr	Rb / Sr
AGV-1	66.0	667.3	0.0994
BCR-1	46.9	334.8	0.140
G-2	171.6	478.0	0.3590
GSP-1	256.5	2365	1.0846

Net Rb Kα / Net Sr Kα

Avg. 528 = 0.5033
" 379 = 0.7078
" G-2 = 0.2744
GSP-1 = 0.8260
AGV-1 = 0.0777
BCR-1 = 0.1078

Calculated known Rb/Sr
#528 = 0.6543
#379 = 0.9401

$k = \frac{\text{Rb/Sr known}}{\text{Net Rb / Net Sr}}$

$k_{GSP-1} = 1.313$
$k_{G-2} = 1.308$
$k_{AGV-1} = 1.279$
$k_{BCR-1} = 1.299$
$k_{AVE.} = \underline{1.300}$

Lake County, R. Vargo 3/27/72
65 KVP, 55 ma, LiF (220) peaked on Zr K_α 6.50 V
E = 3.5, ΔE = 15.0

Sample	Start PM	MoKα 30.00	B1 35.40	Sr Kα 35.85	B2 36.50	B3 37.40	Rb Kα 37.99	B4 38.58
	Seconds →	100	100	200	100	100	200	100
AGV-1	1:22	28458	4318	38227	3295	2958	7988	2667
528	1:41	26772	3302	8634	2948	2765	6429	2530
GSP-1	2:00	31272	4041	19462	3411	3183	15927	3007
528	2:19	26661	3330	8665	2988	2775	6465	2534
BCR-1	2:36	22286	3157	17759	2614	2389	5875	2195
528	2:57	26782	3306	8663	3004	2806	6471	2566
G-2	3:16	34038	4797	34844	3756	3401	13667	3106
528	3:36	26675	3290	8587	2973	2774	6450	2530
AGV-1	3:55	28218	4366	37625	3316	2941	7992	2707
528	4:13	26700	3286	8632	2976	2775	6424	2557
G-2	4:32	34028	4777	34661	3748	3381	13607	3100
528	4:50	26539	3346	8590	2952	2776	6404	2549
GSP-1	5:08	31089	4024	19281	3404	3216	15794	2982
528	5:26	26568	3297	8519	2969	2766	6429	2571
BCR-1	5:45	21959	3174	17400	2608	2381	5843	2211

Stop 6:03

	Rb	Sr	Rb/Sr
AGV-1 =	660	664.3	0.0994
BCR-1 =	469	334.8	0.140
G-2 =	171.6	478.0	0.3590
GSP-1 =	2565	2365	1.0846

	MoKαC	Sr base	Sr Kα	Net Sr Kα	Net Sr / MoKαC	Rb base	Rb Kα	Net Rb Kα	Net Rb / MoKαC	Net Rb / Net Sr
AGV-1	28458	7800	38227	30427	1.0692	5625	7988	2363	0.0830	0.0777
528	26772	6314	8634	2320	0.0866	5295	6429	1134	0.0424	0.4888
GSP-1	31272	7566	19462	11896	0.3804	6190	15927	9737	0.3114	0.8185
528	26661	6380	8665	2285	0.0857	5309	6465	1156	0.0434	0.5059
BCR-1	22286	5870	17759	11889	0.5335	4584	5875	1291	0.0579	0.1086
528	26782	6366	8663	2297	0.0858	5372	6471	1099	0.0410	0.4785
G-2	34038	8742	34844	26102	0.7668	6507	13667	7160	0.2104	0.2743
528	26675	6320	8587	2267	0.0850	5304	6450	1146	0.0430	0.5055
AGV-1	28218	7872	37625	29753	1.0544	5648	7992	2344	0.0831	0.0788
528	26700	6318	8632	2314	0.0867	5332	6424	1092	0.0409	0.4719
G-2	34028	8712	34661	25949	0.7626	6481	13607	7126	0.2094	0.2746
528	26539	6370	8590	2220	0.0837	5325	6404	1079	0.0407	0.4860
GSP-1	31089	7540	19281	11741	0.3778	6198	15794	9596	0.3087	0.8173
528	26568	6326	8519	2193	0.0825	5337	6429	1092	0.0411	0.4979
BCR-1	21959	5886	17400	11514	0.5243	4592	5843	1251	0.0570	0.1087

Net Sr / MoKαC averages		Net Rb ave / MoKαC
AGV-1 =	1.0618	0.08305
GSP-1 =	0.3791	0.31005
BCR-1 =	0.5289	0.05745
G-2 =	0.7647	0.2099
528 =	0.0851	0.0418

Net Rb K_α / Net Sr K_α Averages
528 = 0.4917
AGV-1 = 0.07825
GSP-1 = 0.8179
BCR-1 = 0.10865
G-2 = 0.27495

$k = \frac{\text{Rb/Sr known}}{\text{Net Rb / Net Sr}}$

k_{GSP-1} = 1.326
k_{G-2} = 1.308
k_{AGV-1} = 1.270
k_{BCR-1} = 1.289

$k_{average}$ = 1.298

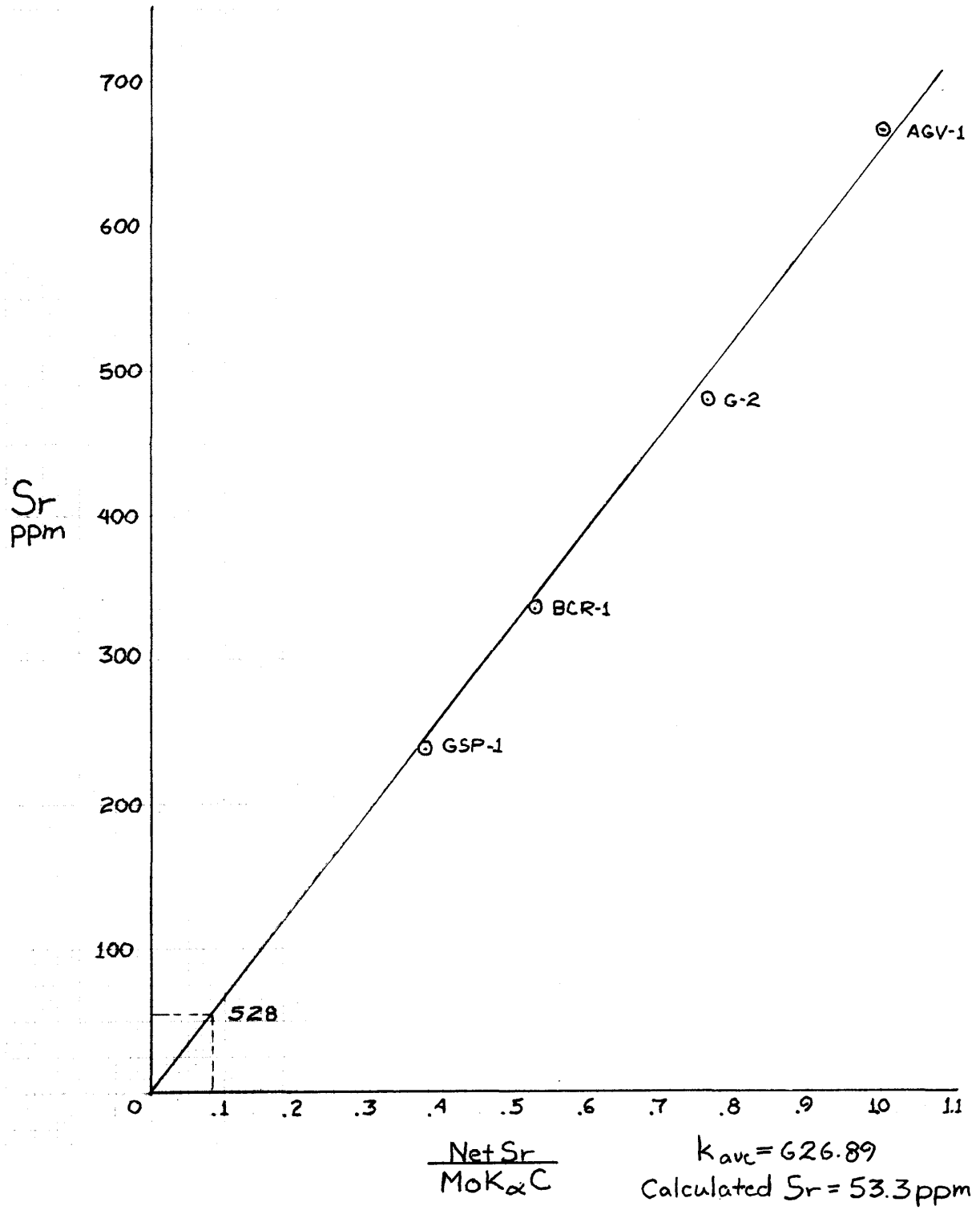

700
600
500
400
300
200
100
0
Sr
ppm
AGV-1
G-2
BCR-1
GSP-1
528
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
1.1
Net Sr / MoKαC
k ave = 626.89
Calculated Sr = 53.3ppm

Figure 6

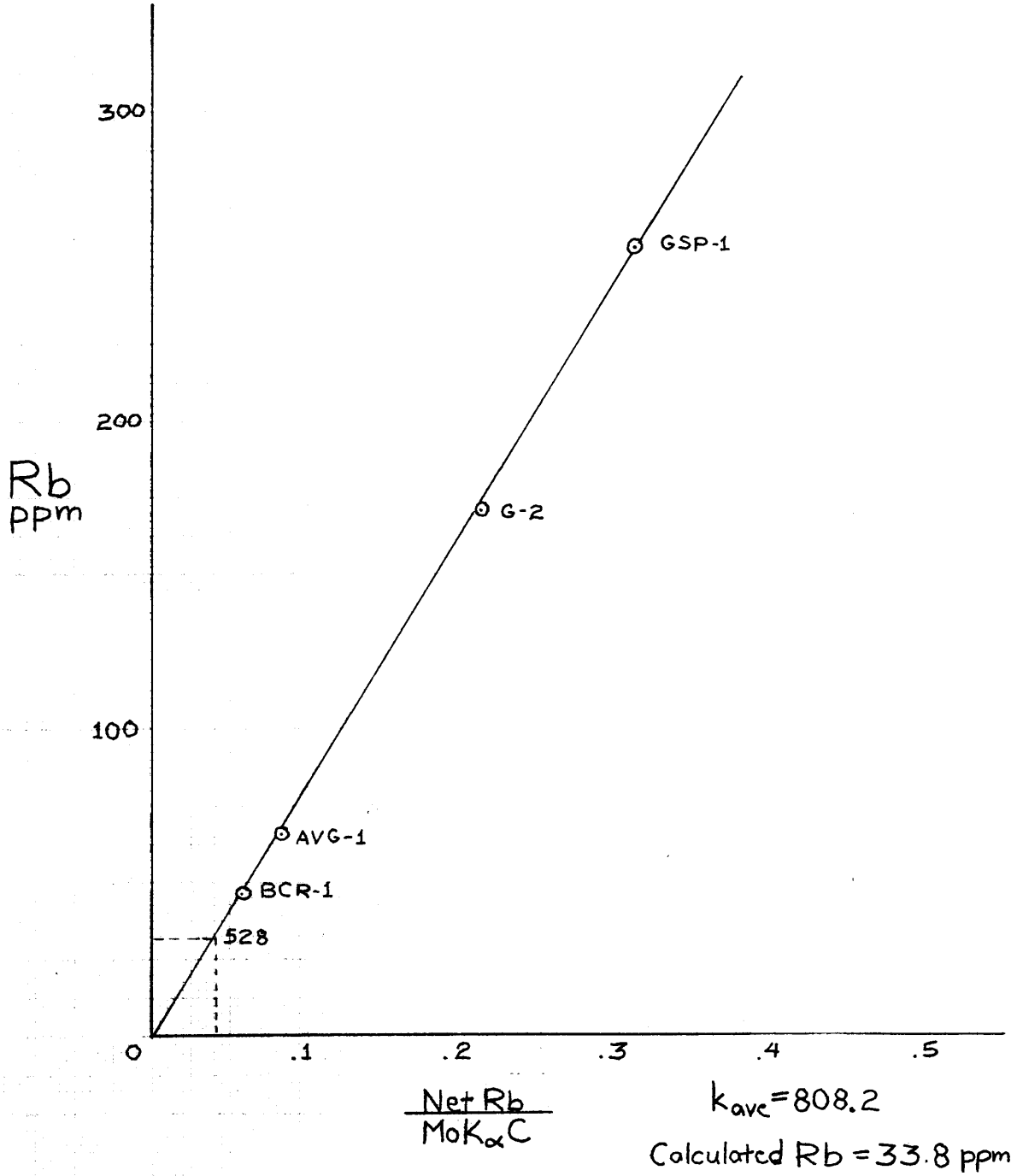
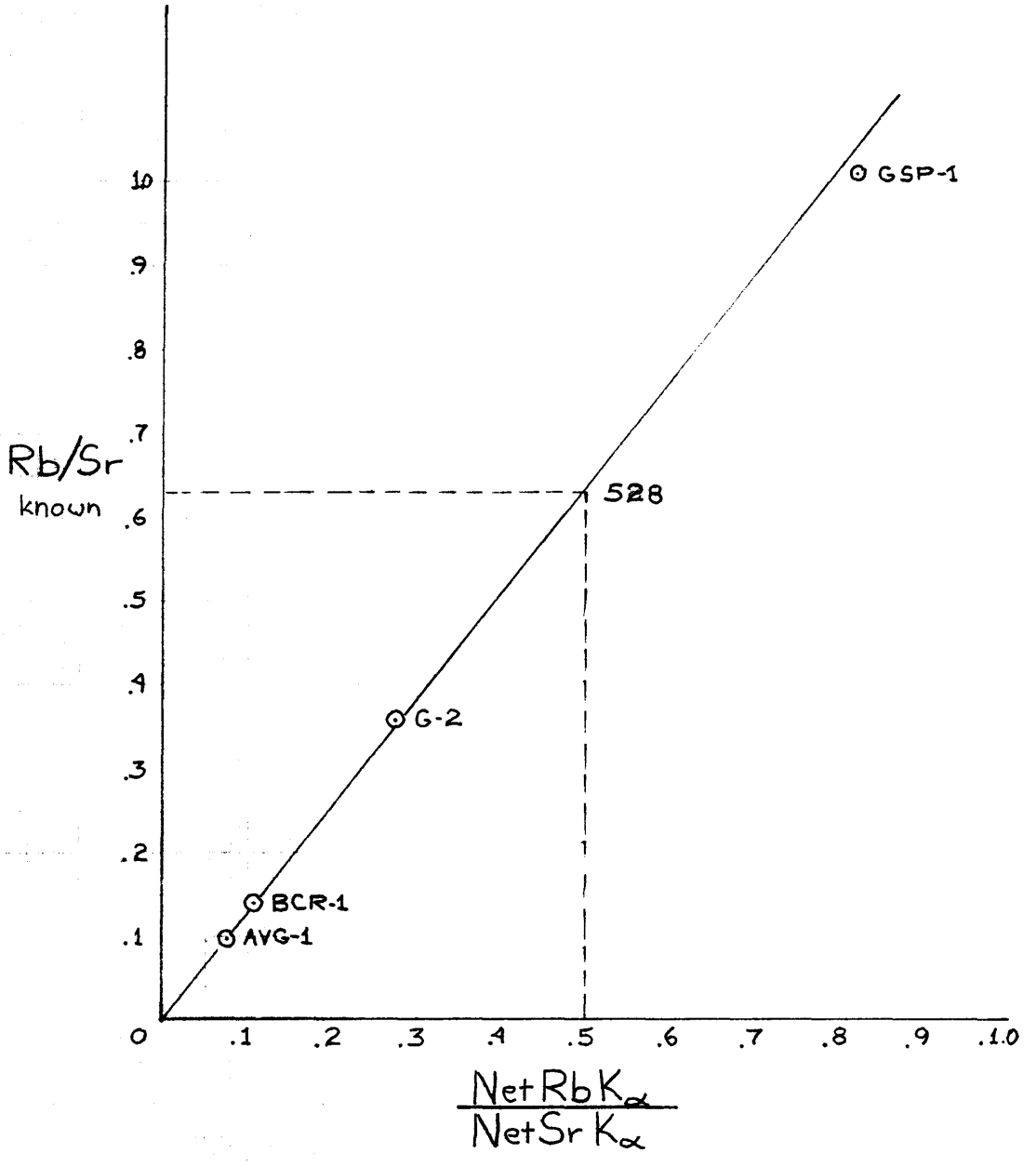

300
200
100
0
Rb
ppm
GSP-1
G-2
AVG-1
BCR-1
528
.1
.2
.3
.4
.5
Net Rb / MoK$_\alpha$C
k_{ave}=808.2
Calculated Rb = 33.8 ppm

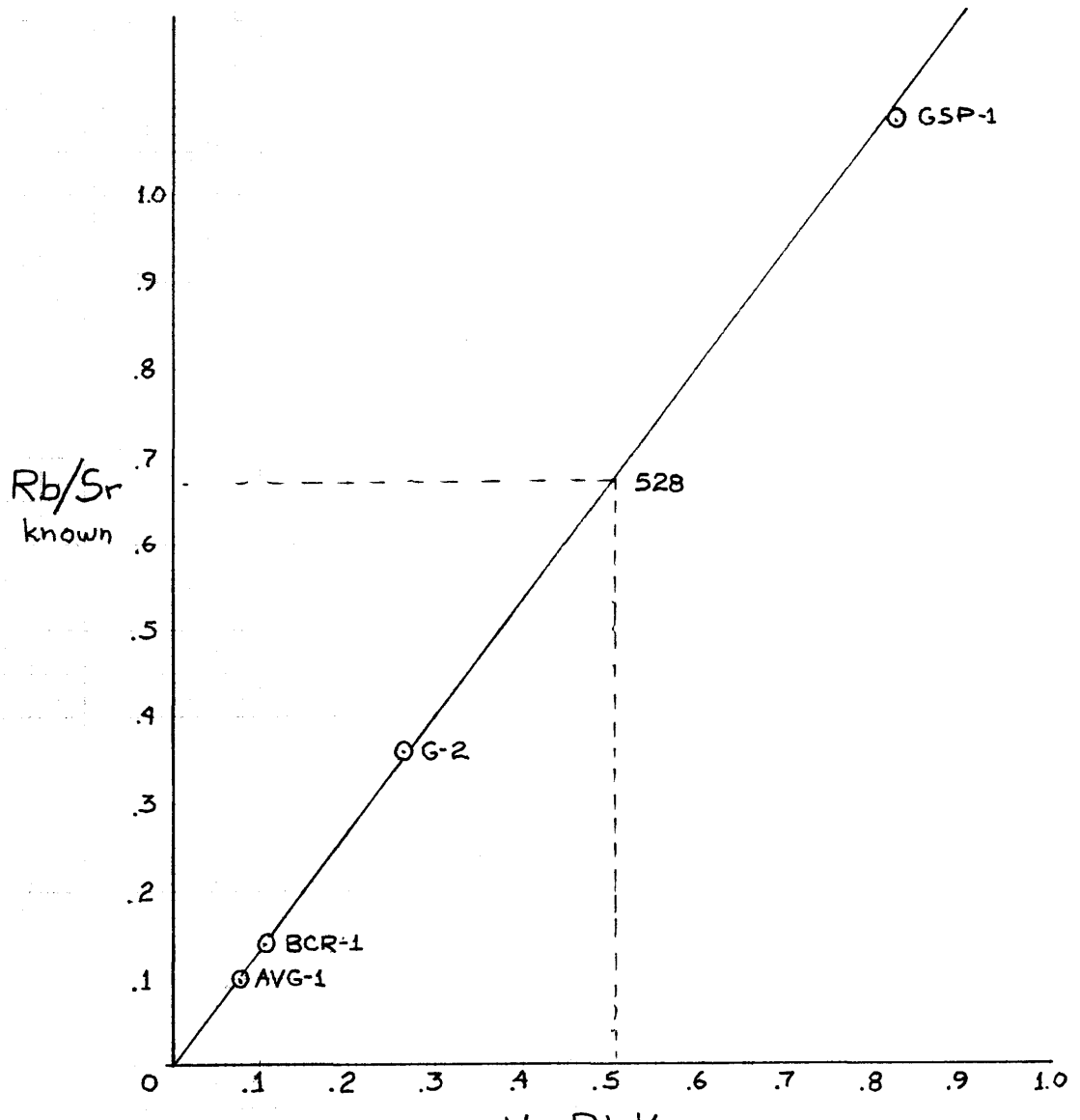
Figure 7



Calculated Rb/Sr
#528 = 0.6382

k_{ave} = 1.289

Figure 8



Calculated Rb/Sr
#528 = 0.6543

$k_{ave} = 1.300$

Figure 9

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